SHORTWAVE LISTENING WITH A CRYSTAL SET

Four parts and headphones

by Phil Anderson

If you've got or can obtain a pair of high impedance headphones, you can add four more parts, wire them together, and listen to shortwave AM broadcasts. No batteries, no extra costs, and just one hour construction time! The four extra parts needed are a .001 µfd capacitor, a 365 µµfd air-variable capacitor, and two coils — which you can wind yourself.

Surprised? Most radio hobbyists think crystal sets are good for the 550-1600 KHz AM band only. However, the basic crystal set works on any band it is tuned to, provided the radio signal is strong enough, and the set is accurately built.

I purchased 75 feet of antenna wire from Radio Shack (RS), wired the set shown in Figure 1, and was able to receive Radio Japan from Tokyo, Christian Science Monitor out of Boston, a German station, and WEWA in Atlanta, all in one night!

The secret to success is to construct the tuning coil, L2, with a large diameter and use heavy copper wire. I used #16 copper which you can purchase at any well-stocked hardware store. I chose a Quick Quaker Oats box to wind my coil on because the diameter is ideal — 5 inches. The coil should be about 3 inches in length and consist of 5-1/2 turns, the turns being spaced one-half inch apart.

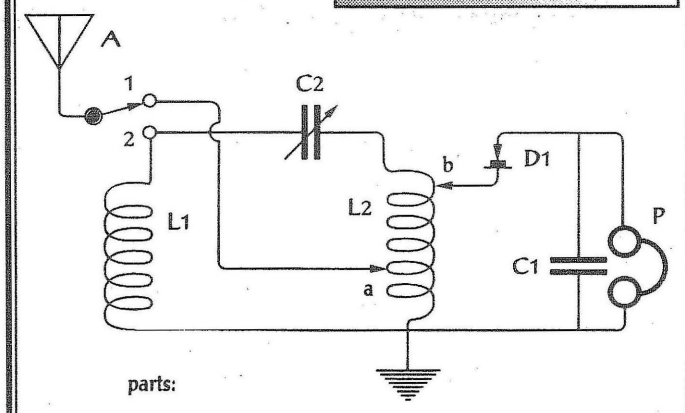
The second secret is to make sure that you use 2,000 or 4,000 (high impedance) headphones. Watch out! Don't use a modern pair; they are only 8 ohms. High-impedance sets are still available; see parts sources.

The remaining parts, C1, C2, D1, and L1 are easy to obtain. C1 and D1 can be purchased from RS, you can wind L1 yourself, and C2 — the 365 µµfd air-variable capacitor — can be found in junk-box radios or from parts sources. I've found lots of 365s at garage sales, inside 25 cent bargain radios! Make an adventure of it; you might find a roll of #16 house wire at the sale, too.

Construction

After winding the tuning coil on the Oats box, I mounted the remainder of parts on a perf board — from RS — and mounted it on top of the box. From there, the components are wired together and the connections soldered. I then soldered clips to each of four pieces of stranded wire and soldered the other ends to the circuit, one each for the leads to the headphones, one for the antenna, and one for a ground clip. At this point the HF crystal set was ready to test!

Figure 1: HF Crystal Set



parts:

A	antenna, 75'	
C1	0.001 µfd cap	
C2	365 µµfd air variable	
D1	1N34 or 1N6263 diode	
L1	0.2 µhenry	0.8" diameter, 0.3" length, 3 turns
L2	3.6 µhenry	5" diameter, 3" length, 5.5 turns (on Quick Quaker Oats Box)
P	high-z headphones, 2,000 or 4,000 ohm	

Calculate the remaining dimensions for a 3.6 microhenry coil wound on a Quick Quaker Oats box:

diameter := 5 length := 3 turns := 5.5

$$L2 := \frac{diameter^2 \cdot turns^2}{18 \cdot diameter + 40 \cdot length} \qquad L2 = 3.601$$

$$wirelength := \frac{\pi \cdot diameter \cdot turns}{12} \qquad wirelength = 7.199$$

Eight feet of #16 copper needed.

Now calculate capacitance, C2, required to put crystal set on frequency:

$$f := 9.5 \cdot 10^6 \qquad C2 := \frac{1}{\left[(2\pi \cdot f)^2\right] \cdot L2 \cdot 10^{-6}} \qquad C2 = 7.794 \cdot 10^{-11}$$

C2 must be 80 uufd roughly.

If we wish to use a dipole antenna, what length will it be, including both sides?

$$dipole := \frac{492 \cdot .95}{9.5} \qquad dipole = 49.2$$

Each side of the dipole is therefore roughly 25 feet.

What will the bandwidth of the set be if the headphones are tapped at the center of the tuning coil? That is, what resistance will the detector and headphones present to the tuned circuit if the detector tap is half-way down the coil?

$$Rheadphones := 4000 \qquad tap := \frac{1}{2} \qquad N := \frac{1}{tap} \qquad N = 2$$

$$R2 := N^2 \cdot \frac{Rheadphones}{2} \qquad R2 = 8 \cdot 10^3$$

$$Q := \frac{R2}{2 \cdot \pi \cdot f \cdot L2 \cdot 10^{-6}} \qquad Q = 37.217$$

$$bandwidth := \frac{f}{Q} \qquad bandwidth = 2.553 \cdot 10^5$$

This bandwidth is pretty wide. IF N is increased to 3, the bandwidth drops to about 100 Kilohertz.

Figure 2: An HF Crystal Set

Listening to distant stations

With most radios, the first instruction is to 'turn the power on.' Hey! This set needs no power, so let's skip that step.

You install this set by clipping the headphones on, attaching a ground, and initially clipping the antenna a couple of turns from the bottom of the tuning coil (the bottom is the ground end). You'll note, from Figure 1, that the anode side of the detector diode is also 'clipped' onto the coil. I start with the diode attached at the top of the tuning coil (as shown, point b.)

At this point, you'll be ready to start tuning and listening for stations. You'll want to tune the variable capacitor very slowly, since the set is capable of tuning from about 4 to 12 MHz. Most HF AM broadcasts will be found with the capacitor at mid-range, and most signals will be heard only at night. Some stations may be found during the day with the capacitor fully open, or nearly so.

With the capacitor set at mid-range, I was surprised to hear Radio Japan loud and clear one evening at 11 PM. I've not heard it again. I can, however, listen to The Christian Science Monitor, at 5.85 or 9.5 MHz nearly every night with good volume. I also found WEWA, Atlanta, at roughly 6 MHz, the first night I listened.

How well it works depends on where you live

Shortwave signals can often be heard several thousand miles away but not at tens of miles! When you

Parts Sources

Amateur Radio Relay League
225 Main Street
Newington, CT 06111

Antique Electronic Supply
6221 S. Maple Ave.
Tempe, AZ 85283

MIDCO
P.O. Box 2288
Hollywood, FL 33022

Mouser Electronics
370 Tomkins Court
Gilroy, CA 95020

Radio Shack, misc.parts

are too close, the signal simply skips over you. At long distances the ionosphere (60 to 120 kilometers up, several layers, and varying all the time) can act as a mirror reflecting signals back to earth. If you are in the right spot, on a given day, at a given hour, you'll hear a distant station broadcasting.

If you use a dipole instead of an end-fed antenna

Most listeners use the easiest antenna to construct — an end-fed wire. You simply run 60 to 80 feet of wire out a window, attach the other end to a pole or tree, and listen! However, it is possible to be a bit more selective by cutting a dipole for the listening frequency of interest.

For example, suppose you'd like to listen to the Christian Science Monitor on 9.5 MHz. In this case, you could cut a dipole of 49.2 feet. One-half of the wire would serve as each side of the dipole and you could then bring the signal into the house with coax cable. (If you are unfamiliar with the dipole antenna, we suggest that you refer to the *Amateur Radio Handbook*, from the American Radio Relay League (ARRL), see parts sources.)

If you chose to use the dipole, switch the antenna input to point 2 on the crystal set (see Figure 1). L1 aids in matching the 70 ohms of the dipole antenna to the high impedance of the tuned circuit. All calculations are shown in Figure 2.

Fine tuning

It is likely that you will encounter several stations at once when listening. This is the nature of crystal sets. The selectivity of the set is usually not sufficient to separate strong stations that are close to each other in frequency. However, it is sometimes possible to increase the selectivity and not lose too much volume by moving the tap of the diode, D1, down on the tuning coil, L2. Experiment with both taps a and b if interference results.

The amazing world of high frequency radio

You might consider logging the stations you hear. Later, you can look at the log and note how HF radio conditions vary from day to day. It will become quite evident to you, even in the first evening of listening, that modern-day radios have hidden from you the variable nature of shortwave listening. Stations will come and go — ebb and flow — over the evening. And if you haven't listened to a crystal set before, you'll be amazed at the quality of the audio.

Welcome to the real world of radio! **NV**

Phil Anderson is president of the Xtal Set Society. To join the society and receive the bi-monthly newsletter, remit $9.95 to: The Xtal Set Society, P.O. Box Z8Z41, St. Louis, MO 63132.

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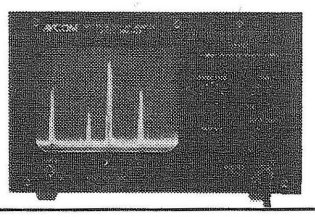

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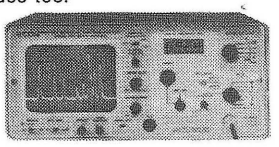

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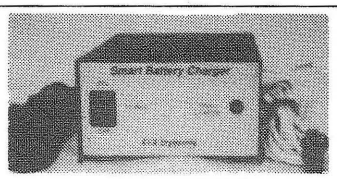

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FOR SALE: Ten-Tec Model 4229 antenna tuner. 2KW. manuals. $100 plus UPS. Jack, KO8I, 38700 Ann Arbor Trail, Livonia, MI 48150. Also Heath IB-1100 freq. counter with IB-102 scaler, manuals. $35 plus UPS.

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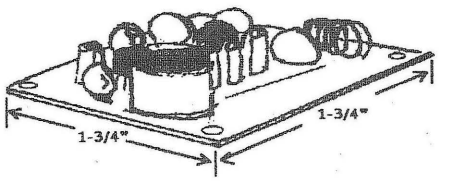

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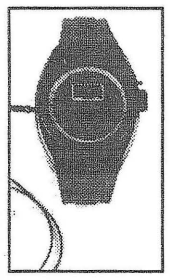

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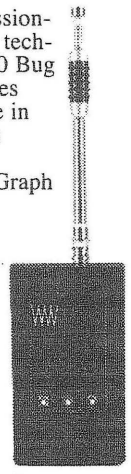

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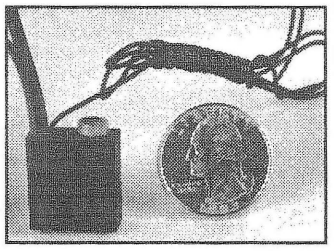

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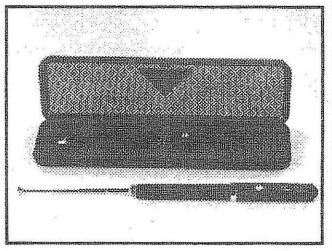

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